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In the November number will appear:

The food of green plants, by CHARLES R. BARNES, *University of Wisconsin, Madison.*

Popular names of American plants, II, by MRS. FANNIE D. BERGEN, *Cambridge, Mass.*

Plants hurt by a late freeze, by P. H. ROLFS, *Florida Agricultural College, Lake City.*

The bacterial flora of the Atlantic ocean in the vicinity of Woods Holl, *continued.*

a
b

C.E. Paxon, del.

B. Mansell, lith. Boston

FRUCTIFICATION of JUNIPERUS COMMUNIS, L.

BOTANICAL GAZETTE

OCTOBER, 1893.

The fructification of Juniperus.[1]

JOHN G. JACK.

WITH PLATE XXXIII.

With rare exceptions most of the plants of our American flora ripen their fruit during the same season in which the blossoms are produced. Among ligneous plants in North America the only noted deviations from this rule of nature are found among the true pines, or genus Pinus as it is now limited and defined by most systematists, and in that section of the genus Quercus classified under Melanobalanus or black oaks.

These trees are monœcious and blossom in the spring or early summer, the young fruits being only partially or slightly developed at the end of the first season's growth and not ripening until the autumn of the second year. The sequoias of California are also said to be biennial fruited, and it has been stated that the cones of several species of Pinus require three seasons to arrive at maturity.

The witch hazel, *Hamamelis Virginiana* L., and the seaside alder, *Alnus maritima* Muhl., differ from these in only requiring one season of growth from the flower to the ripe fruit, for although the blossoming takes place in the autumn, the young ovary makes little or no growth before the following spring, and it becomes fully developed and ripe in the ensuing autumn when the plant is again in flower, so that just a year elapses between the time of flowering and the maturing of fruit; while among the black oaks and the pines, in this latitude, the time necessary for maturation approximates eighteen months, or two summers and one winter.

[1] Read before section G, A. A. A. S., Madison Meeting, August, 1893.

Except the pines and sequoias, all of our other coniferous trees are commonly credited with being annual fruited, although various authors have distinctly stated that the junipers or savins are biennial fruited.

Dr. Asa Gray in his manuals leaves us to infer that the junipers are annual fruited, and so do Emerson,[2] and Chapman.[3]

Bigelow[4] says of the fruit of Juniperus communis that "it requires two years to arrive at maturity from the flower," but makes no observation as to J. Virginiana, so that it would be assumed to be annual fruited; and Wood[5] makes the same record.

Watson[6], in giving the characters of the genus Juniperus, states that the fruit only arrives at maturity in the second year, and Coulter[7] makes a similar note.

Dr. George Engelmann in his monograph[8] says: "The juicy strobil, galbulus, which we may for shortness' sake designate by the popular name of *berry*, matures like the fruit of the oaks and the true pines in the second year, but, unlike them, it attains almost its full size in the first autumn, when even the stony coating of the seed is pretty well formed; but it matures fully a year later. We often observe berries of both years, young and maturing ones, on the same stock; but where it bears only every other year, as conifers often do, fruit of one season and of one state of maturation only is found at one time."

So far as I have been able to examine into the subject, these instances are the only records by American writers where it is distinctly implied or stated that the fruit of Juniperus requires more than one season to arrive at maturity.

Quite a number of European authors record it as a peculiarity, although their testimony is conflicting. The point is not mentioned in some works which might be expected to refer to it.

Behlen[9] says of J. Sabina, J. communis, J. Oxycedrus, J.

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[2]Trees and Shrubs of Massachusetts.
[3]Flora of the Southern States.
[4]Medical Botany, III (1820-45); Fl. Bostoniensis, 1840, 399.
[5]Class Book of Botany, 663.
[6]Botany of California, II 111, 112.
[7]Flora of the Rocky Mountain Region, 429.
[8]The American Junipers of the Section Sabina, Trans. Acad. Sci. St. Louis, III (1877). 586.
[9]Bot. Handbuch, 1824. 269-275.

Virginiana, and others, that the fruit is ripe in the second autumn; and Antoine in his monograph[10] says that both the true junipers and those of the section Sabina take two years to mature fruit, while Carrière[11], in characterizing the genus, says the maturation is biennial, and in the description of our red cedar, Juniperus Virginiana, speaks of the fruit as ripening the second year.

Parlatore[12] says the galbulus ripens the second year. Nicholson[13] says of the genus as a whole: "Fruit berry-like, ripening the second year."

Among those who mark a variation within the genus in time of ripening of fruit we find that Spach[14] says that the maturation of the section Oxycedrus is biennial; of the section Sabina annual or biennial; and that the fruit of J. Virginiana ripens before the end of the same year after blossoming, but persists until the following spring.

Endlicher[15] says that the galbuli mature in the first or only in the second year.

Loudon[16] says of the berries of the common juniper, Juniperus communis, that "they continue on the bush two years;" and he further states[17] that the berries of Juniperus Phoenicea are not ripe "till the end of two entire years." In his summary of the specific characters of the Red Cedar,[18] Juniperus Virginiana, he says: "Flowering in May and ripening in October;" so that he evidently counted it, like most plants, as maturing in the same season that it blossomed.

Boissier[19] divides the section Sabina into five annual and one biennial fruited species, but makes no comment as to the time required by the section Oxycedrus to mature fruit, four species of this section coming within the scope of his work.

In the course of my work at the Arnold Arboretum I have had occasion to specially notice Juniperus communis and J. Virginiana during the past three seasons, and the following

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[10] Die Cupressineen-Gattungen: Arceuthos, Juniperus und Sabina, 1857, 9, 35.
[11] Traité des Conifères, 1867, 8, 44
[12] De Candolle's Prodromus, XVI 2 (1868), 475.
[13] Dictionary of Gardening, 1887, 211.
[14] Ann. des Sci. Natur. III. XVI (1841), 289, 292, 294.
[15] Genera Plantarum, Suppl. IV. 2, 2. Vienna, 1847.
[16] Arboretum et Fruticetum Britannicum, IV (1854), 2491.
[17] See p. 2501.
[18] See p. 2495.
[19] Flora Orientalis, V (1881), 708.

observations may serve to settle this point about the fructification in regard to the only three species which occur east of the Mississippi River. As a rule, they are diœcious, but monœcious examples may sometimes be found.

As is well known, *Juniperus Virginiana* L. is one of the most widely distributed of our American trees, ranging in the east from the northern boundaries of the United States, to Florida, and westward to the Pacific coast.

In New England I find it is simply annual fruited, flowering about the latter part of April and maturing its fruit in the autumn of the same year. In examining specimens from other parts of the country, especially from the south, this characteristic of ripening in the same season seems to be constant. We find no green fruit on the plants in winter, and before spring the trees are often stripped of their ripe blue fruit by birds. The persistence of the fruit during winter and even through the following spring may have given rise to the impression that it was biennial. The galbulus is usually somewhat irregular, normally contains two seeds, and is composed of about three pairs of coalescing scales.

I have not been able to study living plants of *Juniperus Sabina*, var. *procumbens* Pursh., the only other eastern American species of the section Sabina; but, through the courtesy of correspondents, I have had fresh specimens at different stages. This species proves to be very distinctly biennial fruited, the large galbuli and the seeds ripening in the autumn of the second year. The galbulus, formed by the consolidation of six fleshy scales, in three pair alternately arranged, is usually more or less irregular instead of being perfectly round, and in the first season it attains three-fourths or four-fifths of its ultimate size.

The third and last of our eastern American species is the low-growing common juniper, *Juniperus communis* L., belonging to the section Oxycedrus, having three leaves in a whorl, and a native of the old world as well as the new. Very naturally, it has been much studied and monographed, and yet an important peculiarity of its fructification seems to have escaped notice. Instead of requiring only one year, as does Juniperus Virginiana, or two years, as is the case with Juniperus Sabina, var. procumbens, the fruit of Juniperus communis does not mature until the autumn of the third year after blossoming.

In the region about Boston this species generally blossoms from about the middle to near the end of May, or just about a month later than Juniperus Virginiana. The flowers appear in the axils of the leaves from well developed buds on the twigs of the previous season's growth.

The male flower, or catkin as it is sometimes called, is composed of five or six whorls of scales, three in each whorl, each scale usually bearing three or four anthers filled with globular slightly roughened pollen grains about one-fortieth of a millimeter in diameter.

The female flowers consist of three fleshy, tubular, pistil-like terminal organs, commonly considered as ovules, but whose position suggests scales, and by which term I shall provisionally refer to them. Outside of these and alternate with them are three obtuse, very short, thin, fleshy scales not noticeable at flowering time, and with the lower parts of their edges joined together and their inner surfaces connected near the base with the seed bearing scales. These are surrounded and protected by five or six whorls of pointed imbricated scales in alternate series of three like the leaves. When stripped of these outer scales the six inner ones, which ultimately form the seed and fruit, are hardly more than a millimeter in length; or, including the scaly covering, the whole length is nearly two millimeters. The upper ends of the three terminal fructiferous or seed bearing scales protrude beyond their scaly covering like three hollow pistils—they are called styles by Baillon[20] and some others—and diverge slightly outward from each other.

From each orifice there is exuded, when in perfect condition for fertilization, a minute globule of clear shining liquid which rests like an iridescent bubble on the tip and serves to catch the pollen and conduct it to the nucellus or ovule within.

After fertilization the tips of the tubular fructiferous scales seem less prominently exserted and except by a thickening around the base, no apparent growth takes place during the entire summer, so that by autumn or winter the little galbuli are still not much more than a millimeter long. In this condition they look like buds and probably have usually been mistaken for such.

During warm days early in the following month of May, in the climate of Boston, an appreciable increase in size is ap-

[20] Histoire des Plantes, XII (1892). 8.

parent, and a little later, or when the plants are again in good bloom, the year-old galbuli have grown to about four millimeters in length and nearly as large in diameter, the three fleshy enveloping scales having grown rapidly and become almost perfectly coalesced or consolidated around and above the three inner or seed-bearing scales, the outer protecting minute imbricated dry scales making no growth and being shoved aside and left at the base.

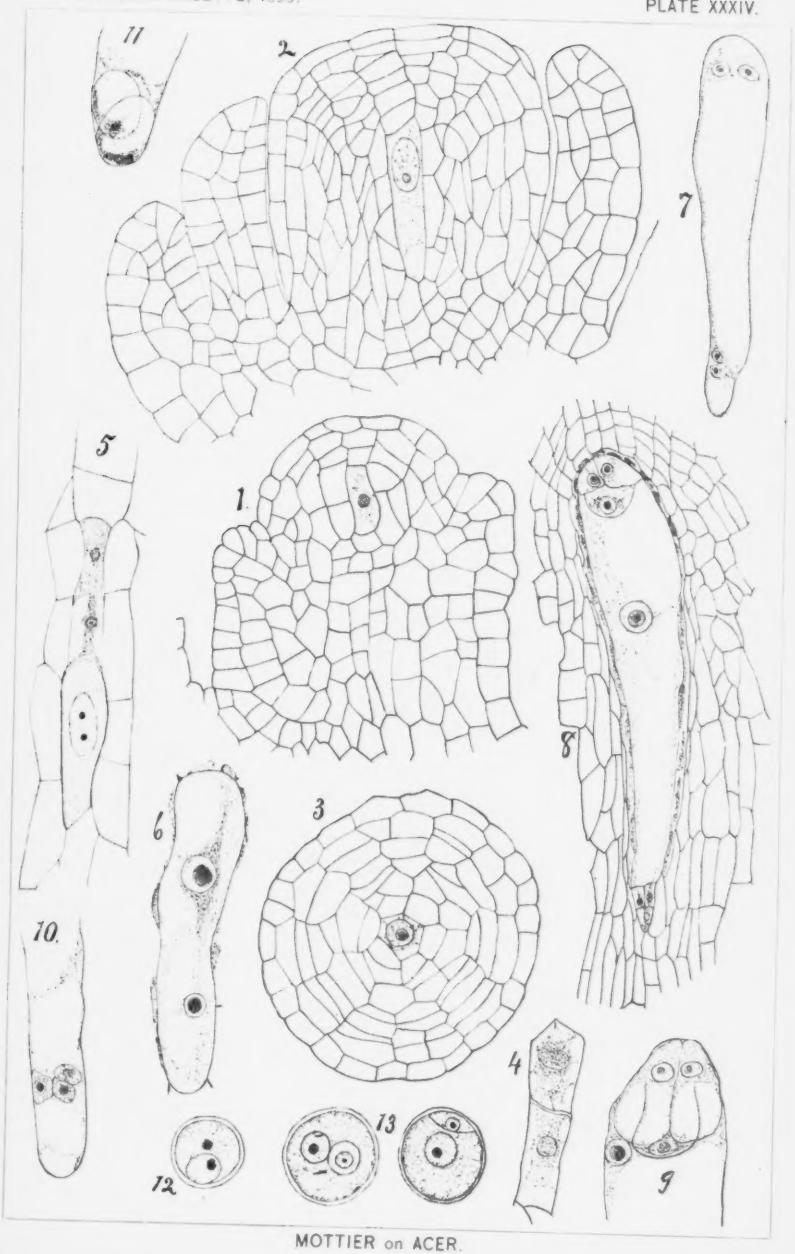
Growth and development are continued throughout this second summer and by the end of the second autumn the galbuli have attained to three-fourths or four-fifths of the ultimate size, and are still quite green without and within. The seeds are filled with soft milky immature albumen.

In the third spring and summer the albumen grows firm and solid, the process of hardening being gradual from the center toward the circumference, the differentiation taking place being quite plainly seen on making a cross section of the seed at the end of May or early in June. About the end of summer the fruits or galbuli begin to change color and assume the bluish or bluish-black color characteristic of maturity. The outer fleshy portion of the fruit changes from a green and hard texture to a soft mealy one, having a somewhat resinous sweet flavor. It is now, in the autumn of the third year from flowering, fully ripe and in a condition to germinate or be eaten by birds.

When not properly fertilized, or when otherwise imperfect or injured, the immature fruits often turn purplish and shrivel in the second season.

Some of the published figures of the fruit of Juniperus communis show the tips of more than three scales as forming the outer fleshy covering, another whorl of scales being represented with the tips showing around the sides of the galbulus. In fact, there are only three scales which combine to form the entire outer part of the fruit in this species; and at maturity their tips have become smooth and rounded, and of course are only to be noticed around the top or crown, leaving the sides perfectly smooth to the base. These scales at flowering time were not noticeable, being hidden, as already stated, beneath the outer leafy protecting scales.

I have not had enough or sufficiently fresh material to secure accurate data as to the length of time required to mature fruit among western species of Juniperus and those from



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the Old World. Of course it is to be expected that Juniperus communis, which is indigenous in both Europe and Asia as well as North America, requires the same time to mature fruit in all regions. *Juniperus rigida* Sieb. & Zucc., of Japan, apparently also passes three seasons before arriving at maturity; but it seems hardly likely that all the species usually classed in this section, Oxycedrus, take so long before reaching full development. In the genus as a whole, probably a large proportion of the species ripen their fruits at the end of the second season; and there are others, besides Juniperus Virginiana, which mature their fruit in the same year in which they blossom.

It is almost impossible to determine these points with accuracy from ordinary herbarium specimens as they are generally collected, and, in making a study of the length of time required by the fruit of different species to arrive at maturity, herbarium material should be collected with special regard to this character; or, still better, the living plants should be carefully observed whenever possible.

For the accompanying plate and other assistance I am indebted to Mr. C. E. Faxon.

Arnold Arboretum, Harvard University.

EXPLANATION OF PLATE XXXIII.—Fructification of *Juniperus communis* L. Fig. 1. Male branch with flowers. Fig. 2. Female branch, flowers and fruit. *a*. Flowers. *b*. Fruit, one year old. *c*. Fruit, two years old (May 25), not mature until autumn. Fig. 3. Male flower, enlarged. Fig. 4. Scale of male flower, exterior view enlarged. Fig. 5. Scale of male flower, interior view, enlarged. Fig 6. Female flower, enlarged. Fig. 7. Fruit one year after flowering, transversely divided, enlarged. Fig. 8. Fruit two years after flowering, transverse section, enlarged. Fig. 9. Seed, two years from flowering, showing resin glands on the back, enlarged.

Development of the embryo-sac in Acer rubrum.

DAVID M. MOTTIER.

WITH PLATE XXXIV.

A study of the development of the embryo-sac of *Acer rubrum* L. presents in itself nothing new or striking, but from the standpoint of comparative morphology it is not wholly without interest. This work represents only a part of a series of similar investigations to be made upon various angiosperms of both related and widely separated families.

Flowers of Acer rubrum in earlier stages of development may be obtained in winter and early spring, by removing the scales and fine silken hairs that enclose them in the bud. From buds taken in the latter part of March (the same condition may be found earlier), the ovules in the young female flower were in the stage of development represented in fig. 1.

In the apex of the nucellus will be found a cell much larger than the other cells, and with more densely stained contents. This is the mother-cell of the embryo-sac. At the time work was begun upon this subject I was unable to find flowers with younger ovules. The mother-cell, in all probability, arises from a single hypodermal cell, but as growth proceeds it soon becomes more deeply situated in the nucellus by the multiplication of the epidermal cells by tangential or periclinal divisions (fig. 2). A transverse section of the nucellus in this stage of development is shown in fig. 3, the larger central cell with large nucleus being the mother-cell of the embryo-sac. This cell which has now elongated considerably divides by a wall at right angles to its long axis (fig. 4). The upper cell divides again in a similar manner, so that there are three cells resulting from the mother-cell (fig. 5). The lower one of these three now enlarges gradually absorbing the two upper; its large nucleus soon divides, and the resulting nuclei move away from each other toward opposite ends of the cell (fig. 5). The further behavior of these nuclei is similar to that which obtains in all known embryo-sacs of angiosperms. The embryo-sac continually increases in size at the expense of the tissue of the nucellus immediately surrounding it.

The mature embryo-sac is broad at the micropylar end, but narrows gradually toward the antipodal end, which is occupied by the small antipodal cells (fig. 8). Here, as in almost all plants, one sees a considerable variation in the position of the endosperm nucleus. It may be close to the egg-apparatus (fig. 9), or more nearly midway between the ends, but always imbedded in the layer of protoplasm lining the interior of the sac, the central cavity of the sac being occupied by one or more large vacuoles. Here, however, the antipodal cells remain very small and their presence can be demonstrated only with considerable difficulty. They are soon absorbed after the embryo-sac is mature, the latter all the time increasing rapidly in size, especially if fertilization be effected.

One case was observed in which the three antipodal cells lay close together without cell-walls (fig. 10). In fig. 11, two naked cells may be seen with large vacuoles. These appeared to be undergoing disorganization.

The process of development in the embryo-sac of Acer rubrum is similar to that which takes place in few families of both monocotyledons and dicotyledons.[1]

It may be of interest to note that the pollen spores formed in the anthers of female flowers (fig. 12), though never becoming functional, develop normally. They are, as far as observation goes, almost precisely like those of the functional male flowers (fig. 13) with the two nuclei present which stain similarly to those of the functional spores. They are, however, smaller, one of the nuclei having a less definite membrane and the protoplasm consisting of a coarser reticulum, while the protoplasm of the functional pollen spores is of a more finely reticulated structure (fig. 13).

In female flowers, when the ovule has reached the stage shown in fig. 2, the four pollen spores have already been formed; the tetrads are, however, as yet enclosed by the wall of the mother-cell. Shortly after the flower opens these anthers shrivel and dry up.

The material for this study was fixed in a one per cent. aqueous solution of chromic acid, washed, stained *in toto* with alum cochineal, imbedded in paraffin, and sectioned on a Minot microtome, after which the sections were counterstained on the slide with a seventy per cent. alcoholic solution of Bismarck brown and mounted in Canada balsam.

Indiana University, Bloomington.

EXPLANATION OF PLATE XXXIV.—Fig. 1, longitudinal section of young ovule; embryo-sac mother-cell with contents indicated. × 375. Fig. 2, same farther advanced; the outer integument on the right left off. × 375. Fig. 3, cross section of nucellus of a similar stage. × 375. Fig. 4, embryo-sac mother-cell divided by transverse wall. × 560. Fig. 5, embryo-sac mother-cell divided into three cells, the larger, lower one with large nucleus and two distinct nucleoli. × 560. Fig. 6, embryo-sac with two nuclei travelling toward opposite ends. × 560. Fig. 7, these nuclei have doubled and occupy the ends of the sac; a large vacuole occupying the cavity of the sac. × 375. Fig. 8, mature embryo-sac with surrounding cells of nucellus. × 279. Fig. 9, egg-apparatus; endosperm nucleus near it. × 375. Fig. 10, antipodal end, the cells lying free without definite walls. × 560. Fig. 11, two antipodal cells. × 560. Fig. 12, pollen spore of sterile stamen in female flower. × 375. Fig. 13, pollen spores of male flower. × 375.

[1] STRASBURGER: Angiospermen und Gymnospermen, Jena, 1879.

Achenial hairs of Compositæ.

MARY A. NICHOLS.

WITH PLATE XXXV.

In the older systems of classification little attention was given to the anatomical structure of plants. It was sufficient to consider only morphological characters. There is, however, a growing tendency to study the minute anatomy and bring it into requisition, as Engler and Prantl have done in many cases in their admirable work "Die natürlichen Pflanzenfamilien."

Many botanists have made comparative studies of different orders, as Leonhard[1] has done for the *Apocynaceæ*, Kuntze[2] on comparative anatomy of *Malvaceæ* and Schumann[3] on the limits of anatomical variation in the same species. American botanists have not been slow to make use of anatomical characters when they could do so. Thus Engelmann[4] long ago called attention to the valuable characters found in the anatomy of the pine leaf. Later Coulter and Rose[5] made a comparative study of our North American pines. They also studied the fruits of *Umbelliferæ*.[6]

In the difficult task of classifying the order *Compositæ* the most minute details of structure are brought into requisition for the determination of species.

In a paper recently prepared on the style-characters of the *Compositæ*, Chamberlain[7] calls attention to the revisions made in the order since the elaboration of the same by Linnæus who divided it into four groups. He notes the fact that Henri Cassini, Lessing, De Candolle, Bentham, and Gray have made use of the style characters in the arrangement of

[1] LEONHARD, MICHAEL: Beiträge zur Apocynaceen, Bot. Centralblatt. XLV. 1, 33, 65, 97, and 129.

[2] KUNTZE, GEORGE: Beiträge zur vergleichenden Anatomie der Malvaceen, Bot. Centralblatt. XLV. 161, 197, 229.

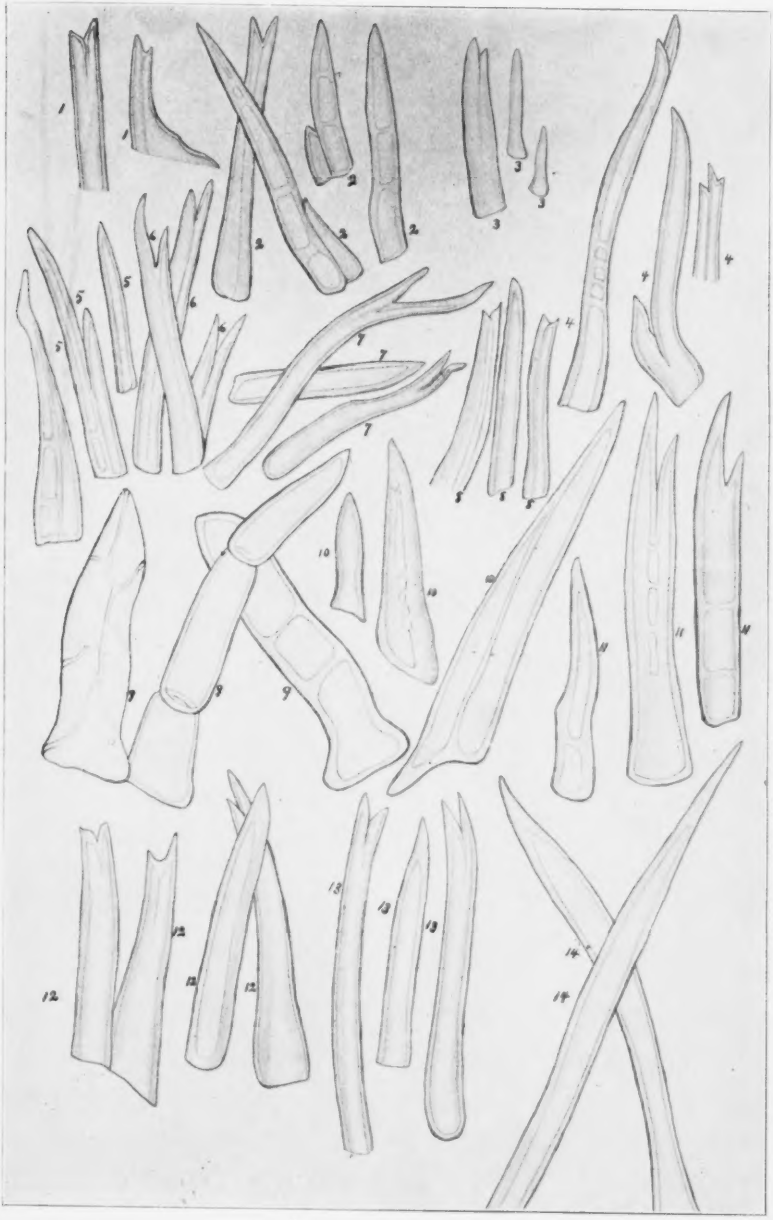
[3] SCHUMANN, PAUL: Beiträge zur Kenntniss der Grenzen der Variation im anatomischen Bau derselben Pflanzenart, Bot. Centralblatt. XLV. 356, 389, and XLVI. 1.

[4] ENGELMANN, GEORGE: Trans. St. Louis Academy of Sciences. III. 595, 602.

[5] COULTER, J. M. and ROSE, J. N.: Synopsis of North American Pines, based upon leaf anatomy, Bot. Gazette. XI. 256, 302.

[6] Notes on Umbelliferæ of East U. S. Bot. Gazette. XII. 12, 60, 73, 102, 134, 157, 261, 291.

[7] CHAMBERLAIN, J. S.: Comparative study of the styles of Compositæ, Bull. Torr. Bot. Club, XVIII. 175.



NICHOLS on ACHENIAL HAIRS.

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the order, and further states that the pappus is of greater diagnostic value than the achenium. Whether or not the statement with reference to the achenia will stand, remains to be shown. Little attention has been given to a microscopic study of achenia but Macloskie[8] and Loöse[9] have both studied the minute structure of the achenia of *Compositæ*.

Gray, in his manual, frequently notes the presence of achenial hairs, but comparatively little microscopic work has been done on the anatomy and physiology of these organs. Hence their value as specific characters remains to be determined.

The hairs on the *Compositæ*, especially those of *Senecionidæ*, are of peculiar interest.

The subject has been discussed by Pammel[10] and references given.

Harz[11] figures achenial hairs on *Taraxacum* and the more or less papillose cells of *Scorzonera*. Loose makes the statement that the anatomical characters of the fruit in a genus are usually alike although exceptions are found in *Anthemis*, *Pyrethrum*, and *Chrysanthemum*. He figures the hairs on *Callistephus Chinensis* and *Zinnia verticillata* in his Fruchtschale der Compositen.

Heineck[12] incidentally refers to the anatomical structure of the hairs on the fruits of *Compositæ*, but he was chiefly interested with reference to their mechanical function.

Macloskie[8] points out similarities of achenial-hair structure in the more closely allied groups and also notes a discrepancy in the group *Cynaroideæ*, which, if this be made a basis of classification, would lead to the division of the group, placing *Carlina* and *Xeranthemum* nearer the *Asteroideæ* while the true thistles, in the absence of hairs, resemble the members of the group *Cichoriceæ*. Macloskie has further described and figured the hairs on different genera of other tribes of this order.

[8] Macloskie, Geo.: Amer. Naturalist, Jan. 1883.

[9] Loose, Richard: Die Bedeutung der Frucht und Samenschale der Compositen für den ruhenden und keimenden Samen, Inaugural Dissertation, Berlin, 1891.

[10] Pammel, L. H: On the seed-coats of the genus Euphorbia, Trans. St. Louis Acad. of Sciences, v, no 3. He gives a list of papers bearing on the subject of mucilaginous cell-walls in this paper.

[11] Harz: Landwirtschaftliche Samen Kunde, II. 843-866. Paul Parey, Berlin, 1885.

[12] Heineck: Beitrag zur Kenntniss des feineren Baues der Fruchtschale der Compositen. Inaugural Diss. 1890.

In the preparation of this paper, two types of achenial hairs have been observed: 1. a simple, pointed hair having, apparently, no median line or division wall; 2. a compound or double hair, branching so as to form a double-pointed apex. The former will be designated as "simple" and the latter, with all modifications, will be included under "duplex hairs," a term used by Macloskie.

Of the entire list studied, the only simple hairs found were in *Rudbeckia* and *Centaurea*.

Those found to bear duplex hairs are *Eupatorium*, *Aster*, *Coreopsis*, *Dysodia*, *Bigelovia*, *Bidens*, *Kuhnia*, and *Liatris*.

As may be seen, this division does not follow closely the established lines of group division. Aside from the digression already noted by Macloskie in the group *Cynaroideæ* may be mentioned the fact that *Centaurea*, of this same group, has long simple hairs. This puts into one group the three possible divisions which may be made with reference to achenial hairs. In the *Helianthoideæ* also several genera, as *Helianthus*, *Coreopsis*, and *Bidens*, present distinct duplex hairs; on *Lepachys* they are of the simple kind and on *Xanthium* and *Silphium* no hairs are found. Among the *Asteroideæ*, the genera *Aster* and *Bigelovia* have conspicuous duplex hairs while on others, as *Grindelia* and *Erigeron*, no hairs are found.

In other groups similar differences occur which would seem to preclude the possibility, or at least the advisability, of accepting these as tribal characters. Within the genus however, the character seems to be more constant and might, perhaps, be made of value in the determination of species.

In *Eupatorium villosum* Swartz the hairs are comparatively short and have lateral canals which appear also to form or to follow the division wall in those duplex hairs in which this wall is visible. Whether the non-appearance of this wall in some duplex hairs was due to the accidental placing of the hair upon the slide or to the fact that this is an inconstant structural character, the writer was unable to determine.

In *Liatris gracilis* Pursh a number of the hairs when first examined appeared simple, but closer investigation revealed, in nearly every case, a rudimentary growth at the base, establishing the duplex character of the hair. In these hairs cross canals were plainly noticeable, especially after the application of glycerine.

The hairs of *Kuhnia eupatorioides* L. present few structural characters and on the whole, seem imperfect. No canals or division walls appear. Many of the hairs are small and show neither the double tip nor the basal rudiment. If these specimens should prove perfect and this irregularity a fixed character it might materially alter conclusions, but it is probable that further examination will prove the hairs of *Kuhnia* to be duplex and these specimens imperfect.

The asters all have long, distinct, duplex hairs. *Aster macrophyllus* L. has some duplex only at the base and in another case three tips were distinguished. The lateral canals are distinct, but their walls are sometimes broken, affording transverse communications. In *Aster laevis* L. are found the same characters. Although in two thirds of the specimens only one tip is visible, yet the hairs have every other appearance of being duplex. The hairs from *Aster oblongifolius* Nutt. are somewhat thicker and have sharply pointed tips. The tip form, however, varies too much within the species to give it any specific value. In many cases in *Aster Novæ-Angliæ* L. the tips are deeply cleft and of unequal length, but here too the variations are so great as not to offer any specific characters.

Bigelovia nudata DC. presents a slight irregularity of appearance. The canals seem to extend through the center of the hair. This may, however, be due to the position and transparency of the hair, which, combined, give to the division wall the appearance of a canal. This supposition seems more probable since in the cases where only one half of the hair is developed, the canals are in the usual lateral position.

Rudbeckia pinnata Vent. introduces us to the group *Helianthoideæ* and presents a marked contrast to any of the preceding. The hairs are much thicker and less acutely pointed. In one case the canals seem to ramify irregularly. In another case the hair appears to be distinctly jointed, while a third form has the usual structure, lateral canals and transverse connections.

In *Bidens frondosa* L., also of the group *Helianthoideæ*, the hairs seem at first to be simple but close study shows irregularities of structure which would make them of the duplex type, at least in the more mature stages. The fact that some of the younger growths are so distinctly simple might indicate that the two parts do not always develop

simultaneously. These hairs also show unusual differences of length.

Coreopsis aristosa Michx. is very similar to the preceding. The hairs are of various lengths and diameters, have lateral canals, and are probably all duplex when perfectly developed.

Helianthus occidentalis Riddell of the same group, is also very similar, except that the tip is perhaps less deeply cleft. Occasional specimens seem simple except for a line through the center, answering to the median wall.

In *Dysodia papposa* (Vent.) Hitchcock, the hairs are rather more slender, double tipped, but show no division wall.

In *Centaurea Cyanus* L. they are very long, slender, and indistinct. No transverse canals are found, and the apex is sharply pointed.

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EXPLANATION OF PLATE XXXV.—1. Eupatorium villosum Swartz.—2. Liatris gracilis Pursh.—3. Kuhnia eupatorioides L.—4. Aster macrophyllus L.—5. Aster laevis L.—6. Aster oblongifolius Nutt.—7. Aster Novæ Angliæ L.—8. Bigelovia nudata DC.—9. Rudbeckia pinnata Vent.—10. Bidens frondosa L.—11. Coreopsis aristosa Michx.—12. Helianthus occidentalis Riddell.—13. Dysodia papposa (Vent.) Hitchcock.—14. Centaurea Cyanus L.

The bacterial flora of the Atlantic ocean in the vicinity of Woods Holl, Mass.

A contribution to the morphology and physiology of marine bacteria.

H. L. RUSSELL.

WITH PLATE XXXVI.

In a previous paper[1] was recorded a series of observations upon the bacterial life of the Mediterranean which were made at the Naples Zoological station during the spring and summer of 1891.

This paper contained a number of facts that had been gathered from a study of the bacterial life of that region, but the area covered was too limited to allow any general conclusions to be drawn concerning the bacterial life of the sea. The importance of a more thorough biological knowledge of the micro-organismal life of the marine waters led to a desire to continue this line of research, so the opportunity offered through the kindness of Prof. C. O. Whitman, Director of the Marine Biological laboratory at Woods Holl, Mass., to carry on a similar line of work at that station was eagerly accepted.[2]

The thorough elucidation of the laws that govern the distribution of this class of organic life can only be made upon extensive data gathered not only under similar but widely diverse conditions. A comparative study of the bacterial flora on this side of the Atlantic with that of the Mediterranean was therefore of importance, so the plan of work this season was practically the same as that of the previous year. Frequent reference will of necessity be made to the previous communication and some of the results that will be detailed here will have been considered before to some extent, but as the conclusions then drawn were only provisionally suggested, the confirmation of them will substantially increase their basis for support.

The main object of the work at Naples was a study of the deep sea bacteria and the sea bottom as well as the water was also examined from the shore line down to a depth of 3,500^{fs}.

[1] Zeits. f. Hyg. XI. 165–206.

[2] The quantitative part of the work was done at this station while the more detailed study of the individual forms was carried on at the biological laboratories of the University of Chicago.

A continuation of the study of the deeper waters was precluded at Woods Holl by reason of the shallowness of the ocean in the vicinity of this port. The shallow continental platform which skirts the eastern edge of the U. S. is here at its greatest width and the broad shoals of Nantucket are even out of sight of land. The conditions however were favorable for the investigation of marine forms in general.

Woods Holl is situated at the extremity of a narrow neck of land that pushes southward from the southernmost point of the Cape Cod peninsula. This narrow land strip is continued seaward in the chain of the Elizabeth Islands and divides Buzzard's Bay, an almost land-locked sea, from Vineyard Sound. This latter body of water separates the mainland and the Elizabeth Island chain from an outer range of islands comprising Nantucket, Martha's Vineyard and others.

The soil of the mainland is of a sandy nature and the general aspect of the surrounding country is that of low hills such as usually characterize a glaciated region. As there are no rivers of any magnitude, and no large cities to add their filth to the ordinary land drainage, the factor of land contamination is here reduced to a minimum.

Both the bodies of water mentioned, Buzzard's Bay and Vineyard Sound, served as a collecting ground for this work. Both are subject to tidal changes; the Sound being swept from end to end by an especially heavy tide.

The physical characters of the sea-bottom of these two bodies of water differed considerably, that of the Sound being of a sandy or rocky nature, while the bottom of the Bay, excluding a narrow littoral belt which is more or less sandy is covered with a uniform sheet of blue or gray silt. No depth within a working distance of the laboratory exceeded 65^{m}, while the 20-fathom line was out of sight of land. Consequently all samples secured were from comparatively shallow depths, although in some cases twenty miles from the main land, with the exception of a few that were taken on board of the U. S. F. C. steamer *Grampus* at a distance of about 100 miles from the coast.

Methods.

The methods used in securing the samples of mud and water to be analyzed were essentially the same as those that were employed at Naples. These methods have been de-

scribed elsewhere, so that a detailed account of them again is unnecessary.[3]

The use of the water apparatus for the second season has confirmed the favorable results obtained during the preceding year. By means of it, a sample of water may be taken from any depth without the slightest contamination from the intervening water masses. The cheapness and ease with which this simple piece of apparatus can be made makes it all the more applicable for its purpose.

The culture technique was substantially the same as used at Naples, so that direct comparisons might be made. Sea water was usually used in the preparation of the agar and gelatine media.

Relation of bacteria to marine waters.

In considering the bacterial content of the sea, attention will first be directed toward the water itself, as a home for bacterial life. When tested by culture methods, the results of the analysis of waters taken at Woods Holl have been of a positive nature, with but two exceptions. Samples were secured under as different conditions as possible, ranging from the surface of the water to the ground layer, and from the shore line to a distance of twenty miles from mainland. The number of germs per unit of volume (1^{cc}) varied within wide limits but to a much less extent than in fresh waters. When extraordinary numbers of bacteria were found in the cultures, one species almost always predominated to a large degree. The possibilities of the introduction of a small bit of floating zoogloea that might happen to be in the water renders this fact easily explainable. If the sample secured contained a fragment of the gelatinous mass of germs, it would be broken up in the preparation of the cultures and the separated germs would develop as isolated colonies and thus raise the normal average.

The following table summarizes the results obtained from the analyses of nearly fifty samples of water that were taken. The figures in the table indicate the average of the whole number of colonies that appeared in all the cultures made from samples at different depths. Those samples that contained enormous numbers and all of one kind were excluded from this set of averages.

[3] Zeit. f. Hygiene, XI. 166. Botanical Gazette, XVII. 312.

DEPTH OF WATER IN FEET.	NUMBER OF BACTERIA PER CC. FOUND IN THE WATER AT DIFFERENT DEPTHS (IN FEET).									
	0	15	20	25	30	35	40	45	50	65
30	6	8	....	....	46	....	....	....	....	....
35	....	....	....	....	....	175	....	....	....	....
40	....	....	3	....	....	....	105	....	....	....
45	....	....	....	16	...	....	....	5	....	....
50	....	....	....	18	....	....	....	....	40	....
55	....	....	....	....	....	....	....	....	....	....
60	....	....	....	....	....	....	....	....	....	....
65	110	....	....	....	120	....	....	....	...	6

As the above table indicates, the limits of variation per unit of volume varied from a few germs to about 120. No especial difference in numbers can be noted in the various depths that may not be ascribed to local variations. The water seems to be peopled at all depths with bacterial life, and the deeper layers appear to be as rich as the more superficial. These results, on the whole, agree quite closely with those obtained at Naples. Although the depth there was much greater, no marked diminution could be detected between the superficial and the bottom layers. Almost every cubic centimeter of water subjected to analysis contained bacteria, usually not exceeding one hundred germs per unit of volume. Karlinski[4] in studying the waters of Lake Borke, one of the fresh water lakes in Bosnia, arrives at a somewhat different conclusion. He finds that the germ life is much richer at the surface and that there is a gradual diminution in numbers as samples from increasing depth are examined. His investigation, however, only extended to the depth of fifty feet. It is surprising that there should be so marked a decrease in numbers as he gives with such a slight change in depth. This is certainly not the case with marine waters already examined, as the analyses made at Naples and at Woods Holl fail to show any law of distribution in this manner.

Whether the great bulk of the ocean waters is inhabited by micro-organisms is not yet positively known, as no bacteriological examination has been made of water at great distances from land. In fact the knowledge that we possess of

[4] Cent. für Bakt. XII. 220.

this class of life in the open ocean is practically nothing, for scientific expeditions have as yet paid no attention to the investigation of these forms.

While we have no direct knowledge concerning their presence in mid-ocean, it is not unreasonable to suppose that they are present throughout the great mass of oceanic waters.

The conditions for their development here are quite as good as are found in fresh water. True it is that many forms in fresh water are of undoubted land origin, but we recognize numbers of species as being so well adapted for development in water alone, that they have received the name of "water bacteria." As we look upon the sea as the original home of organic existence, it is not at all improbable that these primitive generalized types of life may have been dwellers in the deep from time immemorial.

Although positive proof concerning the universality of bacterial distribution in the ocean is yet wanting, we have the strongest circumstantial evidence and that is the presence of identically the same species on this side of the Atlantic that have been found in European waters. This point will, however, be considered later in another connection.

The gradual disappearance of bacterial life in fresh water lakes as the distance from the shore increases has led some to think that bacteria are present in sea water in only limited numbers. They regard the presence of micro-organisms as evidence of land contamination and where this disturbing factor is excluded, the normal number of bacteria is regarded as extremely small. That there is a marked diminution in germ life as we recede from the shore is undisputed, but this decrease soon reaches its minimal point and then the proportion remains fairly constant. Even where the condition for introduction of land-derived forms is as favorable as it is in the harbor of a large seaport, the point of minimal diminution is usually reached within a distance of three or four miles from land. With the ordinary coastal drainage the influx of fresh water forms does not affect the average content to as great a distance as this.

A comparison of germ life of salt with that of fresh water shows that the latter is usually much richer in bacteria. The principal reason for this is perhaps the closer proximity of fresh water to the soil layer, the upper strata of which are so rich in bacterial life. Every rain fall brings innumerable

germs to the water level and thus raises the average greatly for the time being at least. Then another cause is the greater rapidity of multiplication in these waters on account of the higher temperature.

Comparisons can scarcely be made under equal conditions between the bacteria found in streams and springs and those inhabiting the ocean. The proportions existing between the waters of our great inland seas and that of the ocean would be much more reliable but as we have no data concerning the bacterial contents of these large fresh water masses, this can not at present be made.

In the light of our present knowledge, the assertion seems to be warranted that marine waters are not as rich in bacterial life as fresh water masses.

The question of the vertical distribution of bacterial life throughout large bodies of water has a direct relation to the problem of sedimentation. The specific gravity of bacteria cannot exceed very much that of water, especially saline solutions like the sea, yet it would not be unreasonable to suppose that these organisms would slowly tend to settle to the bottom in obedience to a universal law. Especially would this be likely with forms that are in a spore condition, as they are immotile and of higher specific gravity than active protoplasm.

But the question as to whether there is a "perpetual shower" of germ life on the sea bottom is not so easily answered. A number of opposing factors enter into the question and make it difficult to say what actually takes place under natural conditions. The experiments of Bolton, and Hüppe upon the settling of bacteria in tall cylinders do not give any positive answer, for the natural increase by growth is counterbalanced by the constant dying off of old forms.

Motility is another factor of the problem as those germs endowed with locomotor powers are easily able to overcome the effect of gravity.

Cramer[5] who has investigated both the superficial and deep waters of Lake Zurich is unable to note any marked difference in numbers between the surface and the ground layer.

This season's work substantiates the results of the previous year and leads us to the conclusion that the deeper layers are as rich in bacterial life as the surface. Whether this is true

[5] Die Wasserversorgung von Zürich. 1885.

for the abysmal depths of the ocean is hazardous to say. The diminution in temperature as the depth of the ocean increases will of course retard the growth of micro-organisms. The deepest point from which water samples were taken in the Mediterranean (3,200^{ft}) showed thirty germs per cc. but the temperature in this instance was high for deep water as this sea has a constant temperature of about 55° F. below the 600 feet line.

Relation of bacteria to the sea-floor.

When we consider the bacterial flora of the sea-bottom, the results of the analyses of mud show a widely different condition. Micro-organisms are always present in very great numbers. Numerically, as regards the bacterial contents, the sea floor bears a similar relation to the superincumbent water masses that the superficial soil layers do to the atmosphere above. This is only true, however, from a numerical standpoint, for the water does not derive its bacterial life from the sea floor, while the germs in the air have their origin in the soil. In only two instances have I found at Woods Holl forms in the water that plainly showed that they were derived from the slime layers below. These cases are explainable, however, for a heavy tide was noted at the time the samples were taken and it is highly probable that the tidal current detached particles of mud from the bottom and thus the mud bacteria were included in the sample of ground water, although five or six feet from the bottom.

The analyses of the sea bottom that were made at Woods Holl this season covered nearly one hundred tests. Most of the samples were secured from Buzzard's Bay and Vineyard Sound and included material of widely varying physical characters. The area covered was not far from one hundred square miles and included all depths from the shore line to sixty-five feet.

In the ninety-five samples that were analysed from this locality, the average number of bacteria per cc. was about 17,000. In no case was a sample of mud tested by means of culture methods that did not yield bacteria although the limits of variation were wide.

In a few instances, the number of germs present were fully 100,000 per cc., but these exceptional cases are to be ex-

plained in the same way as in those samples of water that far exceeded the general average.

Not much of an idea can be gained from an average like this unless other conditions are taken into consideration.

As there was a wide difference between the physical character of the sea bottom at the various places from which samples were taken, the analyses have been arranged with reference to this point to see what effect the substratum had upon the presence of bacterial life.

The opportunity for a comparison of this nature was all the more favorable at Woods Holl on account of the slight variation in the depth of the water. All samples that were analyzed were secured at depths ranging from 25 to 65ft, so that this factor was fairly constant. According to the analyses made at Naples, this element of depth entered very strongly into the problem of quantitative distribution, there being a marked decrease in numbers as the depth increased.

It has already been ascertained through the investigations of Fränkel[6] and Reimers[7] that virgin soil is much poorer in bacterial life than that which has been disturbed, and that in a general way, the bacterial contents of a soil are largely dependent upon the amount of organic material that is contained therein. As the sea bottom is practically undisturbed as far as the influence of man is concerned, a comparison of the germ life of different soil bottoms ought to yield natural results.

From a mechanical standpoint, a fine silt would offer better conditions for bacterial life than a coarser soil, as there is more room in the interspaces in which the bacteria may develop.

Whitney[8] has estimated the absolute empty space in sand to be 45 per cent. of its volume while that of clay is fully 25 per cent. more.

The majority of the samples that were taken from the sea bottom were either composed of a very fine silt or a fine quartz sand mixed with clay. In several instances, samples of pure "live" sand, as these shifting shoals are called, were also tested as to their bacterial life. Grouping the analyses according to the physical character of the bottom from which the respective samples were derived, it was found that thirty

[6] Fränkel: Zeits. f. Hygiene II (1887). 521.
[7] Reimers: Zeits. f. Hyg. VII (1889). 307.
[8] Whitney: Fourth Md. Agric. Rept. (1892). 281.

tests of the very fine blue and gray silt yielded on the average about 17,000 germs per cc. Thirty-five samples of a mixed quartz sand and clay gave an average of nearly 20,000 germs per unit of measure. The few samples of pure shifting sand were practically free from organic matter and contained only about 5,000 germs. Not enough tests were made to say whether this ratio would be maintained or not, but the difference between the sandy clay and silt is quite within the limits of ordinary variation. The species found in the pure sand did not differ from those growing in the clay soils.

Quantitatively, the marine mud in the vicinity of Woods Holl contains much less germ life than that of the Mediterranean in the vicinity of Naples. The Naples cultures made from mud taken at the depth of 150ft or less, yielded usually from 200–300,000 germs per cc., while those made on this side of the Atlantic in only exceptional instances exceeded 50,000 germs while the average content was about 15–20,000 per unit of volume. Just what conditions bring about such a marked diminution is not easy to see. The figures given for the Naples analyses include only the samples taken at a distance of two miles or more from land. From the appearence of the cultures, this limit seemed to be outside of the influence of land contamination. The majority of sewage and fresh water forms do not find favorable conditions in the sea for their development, but it is highly improbable that all germs introduced in this way are destroyed. Many no doubt adapt themselves to their changed conditions and are able to live. At all events, the conditions at Woods Holl are in all probability more nearly normal than they are at Naples, as the possibility of the introduction of such enormous numbers as would be derived from a large city are in this case excluded.

This season's work has been carried on in much more northern waters but the difference in temperature is not great. The period of observation at Naples extended from April to July, the temperature of the water during this time varying from 60°–75° F. This year the work was carried on somewhat later (June–August), the temperature ranging from 55°-70° F.

Temperature is one of the more important factors that govern the distribution of micro-organisms, but it would seem in this case that the difference in bacterial contents of the

two localities examined must be explained in some other way.

As yet, we do not possess sufficient knowledge concerning the distribution of bacterial life to satisfactorily explain this peculiarity.

Relation of the bacteria of the sea bottom to the superposed water masses.

The idea was advanced as a result of last year's tests that the high content of mud when compared with water was in part due to the growth of distinct species that were to be found *only* in the mud. This indigenous flora was in no way derived from the water masses above but had spread itself over the sea bottom in a way not at present thoroughly understood. This theory was based upon the fact as determined by cultures that at least 35 per cent. of the total bacterial contents of the Mediterranean mud in the vicinity of Naples was included in three species that were exclusively slime bacteria.

The work this season afforded an opportunity to test the correctness of this view on data from a widely different source.

The idea has already gained some ground that the soil bottoms of the oceans have derived their bacterial contents from the water mainly as a result of sedimentation.

This result is based upon the fact that while river water is usually rich in germ life, lake water is poor; therefore it is inevitable that the mud must have derived its bacterial life from the lake water by sedimentation.

Practically no data had ever been gathered on the richness of either lake or sea bottoms in bacterial life from a quantitative standpoint so that the conclusion was mainly an *a priori* one. The results of experimental sedimentation tests do not show that bacteria have any decided tendency toward deposition. The self-purification of polluted streams that used to be explained upon the theory of sedimentation is now accounted for largely in another way and we have no positive experimental knowledge that sedimentation of all these microscopic vegetative forms exists. The results of this season's observations are entirely in conformity with those of the previous year, and indicate beyond a doubt that a large proportion of the bacteria in the mud are inhabitants solely of this habitat.

The majority of the individual germs present are embraced

in a few species. One form, Bacillus limicola, is very common and is almost always found in every culture that is made from the mud. Besides this predominating form there are several other species that are also exclusive mud dwellers. This indigenous mud flora, however, does not make up the entire percentage. In every sample analyzed there is to be found a goodly number of germs that are also inhabitants of the superincumbent water masses. These have not fallen to the sea bottom in a dormant condition, but are actively vegetating, as will be shown in the succeeding paragraph.

The actual stage of development in which marine bacteria are found.

The quantitative analysis of the ocean waters and the underlying floor by means of cultures gives us an approximate idea as to the number of individuals that are to be found therein, but these results do not in themselves tell us the actual condition of the bacteria—whether the germ life is in an actively vegetating condition, or is merely in a quiescent spore stage.

Are the waters of the globe filled throughout with bacterial life in full activity? Is the ocean bottom peopled with forms that are undergoing their cycles of development, or is it merely the resting place for the "perpetual shower" of organic beings from above whose active existence is at an end?

We have determined the presence on the sea bottom of indigenous species, so the most natural inference is that these forms limited to the mud layers must possess the means of carrying on their metabolic activity.

The question can be approached in two ways. One of which is by inferential reasoning and can only be relied upon to the extent of affording a check upon the other method. This is to determine the number of colonies day by day as they appear in the cultures. If the bacteria present are in both a vegetative and spore stage, the time of incubation before the different germs develop into colonies microscopically visible will be quite different. Those germs that are already in an active vegetative condition will immediately begin their growth and with most saprophytic species this will be manifested within thirty-six hours from the preparation of cultures. With those forms that are in a resting stage, the period of incubation will be considerably lengthened. Taking advantage of this fact, we can by counting the number of developing

colonies in the cultures on successive days get an approximate idea as to the actual condition of the bacteria in the sample when it was taken. This method is of course only applicable under certain conditions, for if there is a great variety in the number of different species, the rate of development of the various forms may vary to such an extent as to impair the accuracy of this method.

The method, however, possesses a certain value in the case in hand as the number of species is not large and as it affords a check on the second method which is experimental.

The other method consists in destroying all forms that are in a vegetative state by sterilization at a low temperature. This temperature should not be high enough to injure the germs that are already in a dormant state but should be sufficient to kill all forms having protoplasm in an active condition. The quantitative determination of the bacteria in equal volumes of the sample of water or diluted mud before and after this sterilizing process affords us data for this problem.

Unequal distribution of the germs in the different cultures will materially affect this result, but if proper precautions are taken to thoroughly distribute the bacteria in the fluid before the control cultures are made, this element of error is materially reduced.

Samples of water as well as of mud were subjected to this method of differentiation and were sterilized for one hour at the temperature of 70° C. This temperature is considerably higher than any known form of active protoplasm can endure,[9] so that one may be absolutely sure that all colonies developing in heated cultures originated from sporiferous germs.

Ten series of tests were made with samples taken from the water at varying depths and in all but one of these the "heated" cultures developed bacteria in greater or less numbers. The percentage of sporiferous bacteria in the water varied widely and in two instances the cultures subjected to this partial sterilization showed nearly as many colonies as those untreated. Bacteria, in a spore condition were demonstrated in the superficial water layers as well as at the bottom and intervening depths.

Ten series of tests were also made upon the mud from the sea bottom. These likewise showed a varying percentage of the bacteria present on the sea floor to be in a resting condi-

[9] Except two or three thermophilous species, according to Miquel and Globig.

tion. As in the case with the water cultures the limits of variation with the mud bacteria varied widely. In one instance only (forty-five feet deep) were no bacteria found in spore condition.

These results accord in a general way with those made in the Mediterranean and show that while the water and underlying sea floor are filled with bacterial life, they are by no means in an entirely quiescent condition. Both water and mud are peopled with micro-organisms that are undergoing their cycle of development here as elsewhere.

(*To be continued.*)

University of Wisconsin.

BRIEFER ARTICLES.

Vacation collecting.—I have spent the month of August at Sakonnet Point, Little Compton, R. I. For one week I had the company of Mr. James L. Bennett, who I found had made an extended list of the plants of the region. Among the interesting species are Senebiera Coronopus in great abundance; Woodwardia angustifolia, quite plentiful but not in fruit; and all the queer abnormal varieties conceivable of Onoclea sensibilis.

There is a swamp wood near the house where I am stopping, full of Ilex opaca of large size. I. glabra, I. laevigata, and I. verticillata, also occur. There is a perfect tangle of Mikania scandens, growing high up into the trees. It is rich botanizing all through this swamp. Nowhere did I ever see more brilliant Lobelia cardinalis. We find over forty trees about here, the oak being especially well represented. On all the meadow lands near the sea one finds quantities of Anagallis arvensis. The splendid Hibiscus Moscheutos grows in the salt marshes. I have found no Sabbatias. As curious strays have been picked up now and then in the neighboring town of Tiverton, I am on the lookout for them here. I might say that Physostegia Virginiana is quite common on the roadsides.

In the middle of the swamp wood before mentioned, near a lovely brook, I found a boulder thus inscribed: "To the Memory of Awerstronks, Queen of the Sakonnates, and Friend of the Whiteman." I have spent many happy hours in this secluded spot.

In the early summer I botanized extensively about Mt. Wachusett in company with Mr. J. F. Collins. Afterwards I explored the Taconics with the Harrison brothers, of Lebanon Springs.—W. WHITMAN BAILEY, *Providence, R. I.*

Inter-twining of tendrils.[1]—That the tendrils of certain Passifloræ respond to the contact of one another, and as a consequence form inter-twining coils, was shown in a previous article in this volume, p. 123. In an extension of this work, some attention has been paid to the tendrils of *Micrampelis echinata* (Muhl.) Raf. (Echinocystis lobata.) Chas. Darwin says in regard to this plant:[2] "One of my plants bore two shoots near together, and the tendrils were repeatedly drawn across one another, but it is a singular fact that they did not once catch one another. It would appear as if they had become habituated to contact of this kind, for the pressure thus caused must have been much greater than that caused by a loop of thread weighing only one sixteenth of a grain." He adds, "I have, however, seen several tendrils of Bryonia dioica interlocked, but they subsequently released one another."

The tenor of the paragraph is such that the reader is left to infer that these organs possess such development of the contact sense as to be able to distinguish the contact of tendrils from that of other bodies. This inference is re-asserted in more positive form in many important physiological text books, and the writer would hesitate to offer evidence to the contrary, were not the facts so easily and readily apparent.

It is of interest to know that the plants of Micrampelis echinata, upon which Darwin's observations were made, were raised from seeds sent him by Asa Gray, and the erratic behavior of the tendrils of this representative of an American genus may be due to a changed environment, and climatic conditions. Several plants of this species, growing in a natural situation on the university campus, have been under observation for some time, and all exhibit numerous instances of the inter-sensitiveness of the tendrils. If an active tendril is lightly touched on the sensitive portion of the ventral surface by any part of another tendril, it will form curves in thirty to seventy seconds, while on any one plant can be seen all stages of inter-reaction; tendrils can be found that have recently made contact and formed curves of perhaps forty degrees, others that have formed one or two coils around the grasped portion, and others that have completed the coils and thrown their own free portion into spirals after the manner of mature tendrils. If the tendrils have come in contact at the sensitive part of both, the reactions in each will be similar. The size and elastic firmness of the spirals show that they are functionally normal.

Less frequent examples of inter-twining have also been noticed in

[1] Read before the Botanical Club, A. A. A. S., Madison meeting.
[2] Climbing Plants, p. 131.

the tendrils of *Parthenocissus quinquefolia* (Linn.) Planch. (Ampelopsis quinquefolia Michx.)

From the results of investigation by Haberlandt, Pfeffer, Hofmeister, MacFarlane and others, on various plants showing "contact movements," it appears that none have developed the contact sense in such a manner as to be able to distinguish portions of its own or similar plant bodies from foreign objects, as would be implied in the results of Darwin's observations. Some of the workers named, however, have quoted this statement of Darwin's, but apparently without having confirmed it by actual experiment or observation.

In general it may be safely said that tendrils distinguish only the force of the impact, and roughness of the surface of a body coming in contact with them, and the assertion is hazarded that the inter-reaction of tendrils will be found present in all tendril plants having a habit of dense, vigorous growth.—D. T. MacDougal, *Botanical Laboratories, University of Minnesota.*

CURRENT LITERATURE.

The power of bacteria to penetrate vegetable tissue.

An admirable and much needed piece of work has been done by Dr. H. L. Russell,[1] now of the University of Wisconsin, in adding to and setting in order the scattered knowledge regarding the power possessed by bacteria to penetrate and induce pathological changes in healthy vegetable tissues. He finds from his own researches, what has already been held as highly probable by many vegetable pathologists, that "normally, the healthy plant with intact outer membranes is free from bacteria within its tissues." But this is not due apparently to any marked germicidal properties of plant juices, and in this respect there is a great difference between plants and animals. Many species of bacteria, including animal parasites, plant parasites upon other hosts than those in which they are parasitic, and saprophytes, more especially the last, are able to live for some time, when artificially inoculated, and even to spread through the tissues to a limited extent. In such cases no evident pathological changes are brought about, and the intruding germs eventually disappear.

The method by which germs effect their distribution, which is almost invariably from one cell cavity to another, and not intercellular,

[1] Russell, H. L.: Bacteria in their relation to vegetable tissue; a dissertation presented to the board of university studies of the Johns Hopkins University for the degree of doctor of philosophy. 41 pp. Roy. 8vo. Baltimore, 1892.

was not definitely ascertained; it does not, however, appear to be dependent upon the currents of water in the plant, but is much more closely correlated with the actual growth of the germs.

Only truly parasitic bacteria appear to have power to penetrate the uninjured surface of plants, and not all of this class.

The author does good service by clearly distinguishing between the *resistance* which plants in general exercise toward the inroads of bacteria, and the *immunity* which certain groups of plants are able to maintain toward bacteria that are pathogenic in closely related sorts. The ability of plants to resist the attacks of bacteria is due to both physical and chemical causes. Of the former are "the epidermal and cortical resistant tissues, matured and thickened cell walls of the inner tissue, exclusion by gummy exudates, etc.," and of the latter "the chemical reaction of the juices, the unfavorable conditions of nutrition, the action of the living protoplasm, etc." "The whole question of immunity of plants from bacteria is much more closely related to the same question as regards fungi than it is to the subject of immunity as seen in the animal kingdom."

In an appendix the author has tabulated the prominent facts regarding the several diseases of plants (1) that are with much certainty established as bacterial (thirteen in number) and also (2) of those ascribed to bacteria but the causal relation still uncertain (nine in number). It is interesting to compare this list with that given by Dr. Migula[2] recently. The latter author admits but five into his list of clearly demonstrated bacterial diseases: pear blight, sorghum blight, corn blight (Burrill), rot of hyacinth (Heinz), wet rot of potato (Kramer). Of the remaining eight of Russell's first list, three are European and excluded by Migula, and five are American and evidently unknown to him.

Most of the work in the study of bacterial diseases of plants has been done by Americans, and it is gratifying to have another important paper added upon the subject, also by an American.

Minor Notices.

A SUMMARY of the species of true yeasts, the spore-bearing Saccharomyces, twenty-two in number, is given in the August issue of the *American Naturalist*, by J. Christian Bay.

A LECTURE upon combating the fungous diseases of plants, delivered before the Massachusetts Horticultural Society by Mr. B. T. Galloway, Chief of the U. S. Division of Vegetable Pathology, has recently been distributed. It is an instructive presentation of the subject.

[2] MIGULA: Kritische Uebersicht derjenigen Pflanzenkrankheiten, welche angeblich durch Bakterien verursacht werden. Semarang, 1892.

OPEN LETTERS.

An American Year-book of Botany.[1]

In the July number of the GAZETTE Mr. J. Christian Bay has given an outline of a proposed bibliography of American botany. Owing to the extreme importance of any measure likely to facilitate bibliographic research, I have ventured to make a few comments on the work contemplated. Mr. Bay alludes to the value of Just's Botanischer Jahresbericht and to its supposed neglect of American botanical literature. Now I contend that the neglect is not on the part of the editors of the Jahresbericht but on the part of the American botanists themselves in failing to send copies of their papers to Prof. E. Kœhne, the editor-in-chief. In the preface of vol. 18 for 1890, published in the last heft just received a few days ago, Prof. Kœhne notes some facts which may account for the little attention paid to American literature. In spite of the urgent request published in the preface of the previous volume and elsewhere calling on botanists and societies to send their publications, only the following journals and reports for 1890 were received from America:—An incomplete set of Bull. Torrey Bot. Club; Report Kansas State Agric. College; Journal of Mycology; Proceedings Interstate Convention of Cattlemen at Fort Worth, Texas; Transactions Kans. Acad. Sci.; Contributions from U. S. Nat. Herb.; Report Section Veg. Path., and Scientific Results of Explorations by the U. S. Fish Commission Steamer Albatross! That is to say, only an incomplete set of one private journal, the other six being published by the government. Of American botanists only the following sent papers: J. M. Coulter, F. V. Coville, Th. Holm, F. H. Knowlton, J. N. Rose, W. T. Swingle, S. Watson, and Geo. Vasey. That is, four from Washington, D. C., and four from other parts of the Union!

For 1889 only *three* journals or reports were sent—all published by the government,—and only *six* Americans sent papers! Is it any wonder that we all know "how little attention it pays to American literature!" Yet the facts indicated above do not show the worst phase of the matter. In Europe, thanks to the enterprise of R. Friedländer & Sohn in publishing *Naturæ Novitates* and to similar bulletins issued by booksellers in other countries, we are able to purchase at very reasonable cost any foreign book or paper almost as soon as issued. This is unfortunately not the case for America. Foreigners have the greatest difficulty in obtaining our works or even in learning what is issued. Cases are not rare where American botanists have purchased abroad the works of their own countrymen that by some fortunate chance had been placed on the market. This state of affairs makes it a hundred fold more difficult to obtain American publications abroad than it is for us to purchase the works of Europeans. If other countries should follow our example and start national year-books in their own tongue, in the end the very object aimed at would be defeated and greater confusion than ever would result. It might possibly be advantageous if a year-book giving a full account of the progress of botany in France were issued, but suppose Italy, Holland, Sweden, Hungary, Russia and

[1] Though unavoidably much delayed in publication we deem the subject of this letter of such importance as to justify its appearance at this late day.—EDS.

Japan should follow suit! Yet every one of these countries publishes nearly as much, and several of them more, first class botanical work than is produced in America. How much good would it do American or German or French botanists to have an elaborate year-book in Russian, Polish, Hungarian or Japanese?

To Americans such a bibliography as that proposed by Mr. Bay would be of little value since they are generally well acquainted with the literature as it issues. To foreigners it would simply call for an extra expense to obtain in an unfamiliar tongue what they have a right to expect to find in Botanisches Centralblatt or Bot. Jahresbericht. If the year-book is to reach the widest circle of readers abroad; it should by all means be issued in German or French, or be translated as soon as possible after publication as are Famintzin's *Uebersichten über die Leistungen auf dem Gebiete der Botanik in Russland.*

It is very doubtful whether a publisher could be obtained for such a year-report in German or French unless the author would assume the financial responsibility.

If the work is to obtain the greatest confidence it should be conducted under the auspices of some society or association of recognized standing. Famintzin's reports mentioned above are published by order of the Academy of Sciences of St. Petersburg, the highest scientific body in Russia.

It seems very clear to me that the energy required to carry out the project outlined by Mr. Bay might be spent in some more profitable manner. For instance, prompt and full reviews of American papers might be sent to Botanisches Centralblatt, and authors wishing their papers noticed in Botanischer Jahresbericht could send copies of them to Prof. Kœhne. Of course some persons might feel aggrieved that their second or third rate paper did not receive a highly complimentary two-page notice and might long for a more sympathetic review organ of our own, yet such reasons are hardly sufficient to warrant the outlay of time and money proposed.

It should be remembered that outside of Germany purely bibliographic journals and reports have almost uniformly failed after a few years of precarious existence.

If then French and Italian botanists and American zoologists are able to do without such a year-book it seems quite probable that our own need of such a work is more fancied than real.—W. T. SWINGLE, *U. S. Department of Agriculture, Subtropical Laboratory, Eustis, Florida.*

NOTES AND NEWS.

PROF. J. E. HUMPHREY, formerly of the Agricultural Experiment Station of Massachusetts, intends to spend the coming year in Strasburger's laboratory at Bonn.

IN THE January number of the current volume of the *Forstlich-naturwissenschaftliche Zeitschrift* Dr. F. Ludwig describes a new slime flux caused by one of the discomycetes which he says is identical with *Ascobolus Costantini* Roll.—L. S. C.

THE LIFE and works of Dr. George Vasey are treated in an appreciative article by Dr. Wm. Frear in the June number of *Agricultural Science*, accompanied by a portrait.

MR. RODNEY H. TRUE, lately Fellow in Botany at the University of Wisconsin, has sailed for Germany, where he intends devoting especial attention to vegetable physiology under Pfeffer and others.

A STRIKING illustration of the value of pure culture methods in the study of fungi is furnished by results obtained by Dr. H. Klebahn of Bremen.[1] In an investigation of the pine rust he was enabled to identify six distinct species, all of which had been referred by most authors preceding him to a single species, *Peridermium Pini* (Willd.) Kleb.—L. S. C.

MATURE PERITHECIA of the European grape mildew, *Oidium Tuckeri*, were found in France last November, by G. Conderc (*Compt. rend.* CXVI. 1893, 210), and prove the long suspected identity of the European and American forms. DeBary expressed the opinion in 1875 that the European oidium was the conidial state of the American *Uncinula spiralis*, but it has not been possible before to establish the fact.

THAT SUNDEWS can capture butterflies seems almost incredible, but Prof. J. W. H. Trail in the July *Annals of Scottish Natural History*, records observing upwards of a dozen of the small heath butterfly, Caenonympha Pamphilus, some dead and others struggling violently, which had been caught by the little Drosera Anglica, near Aberdeen, Scotland. These were all seen at one time within an area of a few square rods, although a few single instances had been previously observed.

A NEW SERIES of *fungi exsiccati* is announced by J. B. Ellis and B. M. Everhart to be entitled *Fungi Columbiani*, the first century to be ready by the end of the year. It will include only fungi that have already appeared in the issues of the North American Fungi, and is thus a kind of second edition of that work, but does not embrace all the numbers. The first work has now reached the twenty-ninth century, but many of the earlier volumes are exhausted. The proposed series will be distributed in loose packets, and sold at a somewhat lower price than the other.

A CORRECTION.—In the GAZETTE for September, in speaking of the botanical exhibit made by the agricultural colleges and experiment stations at the Chicago Exposition, it was stated that the part showing diseases of garden crops and fruits was prepared by Prof. Tracy. A note from Prof. Tracy requests us to say that this section of the exhibit was not prepared by him, but that the sheets showing diseases of garden crops were from Profs. Chester and Jones, while those showing miscellaneous diseases of fruits were from Profs. Alwood and Humphrey, and the fine collection of Gymnosporangia was sent by Prof. Thaxter.

THE MEMBERSHIP of the Society for the Promotion of Agricultural Science was increased at the Madison meeting by the election of twenty-one additional members, including the following botanists: H. L. Bolley, Fargo, N. D.; E. F. Smith, Washington, D. C.; F. D.

[1] Kulturversuche mit heteröcischen Uredineen. Forstl.-naturw. Zeits. II. 69.

Chester, Newark, Del.; L. R. Jones, Burlington, Vt.; L. H. Pammel, Ames, Iowa, and S. A. Beach, Geneva, N. Y. The membership of the society is carefully restricted, numbering forty-two for the last year, with a limit of fifty. The limit is now extended to 100. The increase in the society naturally follows the increased interest in agricultural science, and promises to add greatly to the society's usefulness.

DR. ROBERT HARTIG[1] has recently investigated the splitting of olive trees, in Italian orchards. He concludes that the so-called splitting is due to the decay of the tissues occasioned by the attacks of *Polyporus fulvus* Scop. var. *Oleæ* Scop. The spores of this fungus gain access to the inner tissues of the tree through wounds; there they germinate, sending hyphæ in all directions, especially up and down the stem and toward its center by way of the medullary rays. A white rot rapidly follows in the path of the fungus. In many cases wounds occur on approximately opposite points on the stem. Where infection takes place in both of these the decay and falling away of the tissues progresses from both to the center, resulting eventually in the formation of an irregular opening through the trunk with sound wood on either side of it.—L. S. C.

THE LAST NUMBER of the *Journal of Mycology* is unusually heavy, containing one hundred and fifty pages and fourteeen plates. The articles are substantial and contain much valuable data. The articles embracing experimental data are upon wheat rust by B. T. Galloway, peach rosette by E. F. Smith, Cercospora disease of almonds by N. B. Pierce, leaf diseases of nursery stock by D. G. Fairchild, removal of lichens from tree trunks by M. B. Waite, of which the last is especially noteworthy as a new application of the useful Bordeaux mixture. Descriptions of new species of fungi are recorded by J. B. Ellis and S. M. Tracy, and reprint of descriptions from the Connecticut Station reports with additional remarks by Roland Thaxter. Notes on fossil fungi by Jos. F. James, notices of recent literature, and 349 additional entries in the index to literature complete the contents.

THE SOCIETY for the Promotion of Agricultural Science held a successful meeting in Madison, August 15th and 16th. Not as many botanical papers were presented as usual, although more than half the members present were botanists. Prof. C. E. Bessey gave an account of the distribution and abundance of the various species of weeds of Nebraska. Prof. Geo. F. Atkinson described and exhibited illustrations of a new disease (œdema) of apple, forming blisters upon the bark of the younger shoots. Prof. J. C. Arthur spoke of an important law affecting improvement of crops, by which any increase in cultivation, food supply, or other means of accelerating growth, except use of larger seed, increases the vegetative part of the plant more in proportion than the reproductive. A paper was read (in the absence of the author) from W. G. Farlow, upon the occurrence of white huckleberries, mentioning the previously known occurrence of albino forms, and describing his successful search for the white and spotted forms which have been known in Europe but never before recorded from America. He also determined that the change of color in the latter is due to a fungus, probably the same as the European one.

[1] Die Spaltung der Oelbäume. Forstl naturw. Zeits. II. 57.

ENLARGEMENT.

The steady increase in the studies worthy of record which are submitted to the Editors of the BOTANICAL GAZETTE has compelled them during 1893 to print each month *more than the 32 pages promised.* In order to meet the **growing demand for space** and to permit the **prompter publication** of accepted papers, the editors have concluded to

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